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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	
K. Spariosu *et al.*	:	Group Art Unit 2828
Serial No.10/771,047	:	Examiner: Nguyen, Phillip
Filed: 02/02/2004	:	Date: September 29, 2008
For: SCALABLE LASER WITH	:	
ROBUST PHASE LOCKING	:	

AFFIDAVIT UNDER 37 C.F.R. 1.131

Commissioner of Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

We hereby declare that we are the inventors of SCALABLE LASER WITH ROBUST PHASE LOCKING disclosed and claimed in the above-identified patent application.

Enclosed herewith is a copy of an invention disclosure (Exhibit 1), which shows that we conceived the invention before July 25, 2003. We continued to work diligently on the invention until the filing of the Patent as evidenced by the enclosed documents showing diligence timeline and exhibits.

The invention disclosure was sent to Outside Counsel on January 27, 2003 for the preparation of a Patent Application (Exhibit 2). Due to the attorney's backlog of unrelated cases, the case was taken up in chronological order, prepared and filed expeditiously. That is, a first draft was prepared on May 7, 2003 (Exhibit 3). We provided comments on September 15, 2003 (Exhibit 4). Outside Counsel reviewed our comments, conferred with us and revised the draft. A final draft was then prepared on January 26, 2004 (Exhibit 5) and sent to Raytheon. An appointment was made with us to review the final draft and execute formal papers. The Patent Application was filed on February 2, 2004.

Our conception and work on the invention occurred in the United States of America.

We hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of Inventor: Kalin Spariosu
Address: 1262 Calle De Oro, Thousand Oaks, CA 91360
Citizenship: US

Kalin Spariosu 9-29-08
Kalin Spariosu Date

Full Name of Inventor: Alexander A. Betin
Address: 1246 8th Street, Manhattan Beach, CA 90266
Citizenship: US

9/29/08
Alexander A. Betin Date

Exhibit 1

Raytheon

Invention Disclosure Questionnaire

10-5876-2PC (6/00)

Raytheon Proprietary

Complete the information in the spaces provided. Use the TAB key to advance to the next field. Shift-TAB will move the cursor back one field. Either X or Space-bar can be used to check boxes where required.

Prepare the Invention Disclosure Form, except for the information on page 3. The original should be signed and witnessed where indicated. Send the original and three copies directly to the Regional Patent Engineer (see below). Have a copy reviewed and annotated by your department manager (through your immediate supervisor), and then by the manager of the program office or business area most likely to benefit from protection (via patent or trade secret) of your invention. Once you receive the appropriate comments and signatures, the executed copy and six additional copies should also be sent to the Regional Patent Engineer at (see attached instructions):

Inventors at ELCAN, ROSI, and sites in CA or AZ: Intellectual Property & Licensing Dept., Raytheon Company, 2000 East El Segundo Blvd (EO/E01/E150), El Segundo, CA 90245; Texas area: Intellectual Property & Licensing Dept., Raytheon Company, 13510 N. Central Expressway, M/S 200, Dallas, TX 75243; Northeast Region: Intellectual Property & Licensing Dept., Raytheon Company, 141 Spring Street, Lexington, MA 02421.

1. TITLE OF INVENTION

High power Er:crystal fiber-based laser with robust coherent phase locking technique

2. INVENTOR(S) (If more than 3, identify additional inventors in Section 14 and check this box ☐)

(A) NAME (first, middle, last)	EMPLOYEE ID	PHONE	FAX NO.	COMPANY & SEGMENT	DEPT NUMBER
Kalin Spariosu				Raytheon ES	23C725
HOME ADDRESS (street, city, state, zip)		CITIZENSHIP: US	COMPANY MAIL/ADDRESS: 2000 E. El Segundo Blvd. Bldg E1, M/S D109, P.O.Box 902, El Segundo, CA 90245-0902		
E-MAIL: kalin_spariosu@raytheon.com		MANAGER: Maurice Halmos			

(B) NAME (first, middle, last)	EMPLOYEE ID	PHONE	FAX NO.	COMPANY & SEGMENT	DEPT NUMBER
Alexander A Betin				Raytheon ES	23C701
HOME ADDRESS (street, city, state, zip)		CITIZENSHIP: US	COMPANY MAIL/ADDRESS: 2000 E. El Segundo Blvd. Bldg E1, M/S D125, P.O.Box 902, El Segundo, CA 90245-0902		
E-MAIL: kalin_spariosu@raytheon.com		MANAGER: Tom Hastings			

(C) NAME (first, middle, last)	EMPLOYEE ID	PHONE	FAX NO.	COMPANY & SEGMENT	DEPT NUMBER
HOME ADDRESS (street, city, state, zip)		CITIZENSHIP	COMPANY MAIL/ADDRESS		
E-MAIL:		MANAGER			

Patent Department will determine legal inventorship

3. PROOF OF CONCEPTION

A. BY WHOM WAS FIRST DESCRIPTION WRITTEN OR DRAWING MADE?	DATE CONCEIVED	ACCT. CHARGED (TIME/MATERIAL)	LOCATION OF FIRST DESCRIPTION / DRAWING (TECHNICAL NOTEBOOK NO. AND PAGES)
Alexander A Betin	8-15-02	NP1ADH15B1	S149-15R#2 Kalin Spariosu Note Book

B. TO WHOM WAS INVENTION FIRST DISCLOSED?	DATE DISCLOSED	MANNER OF DISCLOSURE
Robert Byren	8-20-02	Verbal with pictorial aid

GOVT REPORTING REQUIRED

PATENTS AND LICENSING USE ONLY

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4. REDUCTION TO PRACTICE

A. WAS A DEVICE EMBODYING THE INVENTION CONSTRUCTED AND TESTED OR THE PROCESS PRACTICED?	YES ☐ NO ☒	BY WHOM	DATE STARTED	DATE COMPLETED	ACCT. CHARGED (TIME/MATERIAL)
B. PRESENT LOCATION OF DEVICE AND ALL DOCUMENTS SHOWING REDUCTION TO PRACTICE					

5. RELATIONSHIP TO GOVERNMENT CONTRACT

A. WAS THIS INVENTION CONCEIVED AND/OR REDUCED TO PRACTICE UNDER GOVERNMENT CONTRACT?	YES ☐ NO ☒	CONTRACT NUMBER AND TITLE
B. TO ASSIST RAYTHEON IN COMPLYING WITH GOVERNMENT REPORTING REQUIREMENTS, PLEASE PROVIDE CONTACT IN GOVERNMENT AGENCY AND RAYTHEON CONTRACTS DEPARTMENT (IF KNOWN). none		

6. RELATIONSHIP TO COMPANY-FUNDED PROGRAM

A. WAS THIS INVENTION CONCEIVED AND/OR REDUCED TO PRACTICE AS PART OF A COMPANY-FUNDED PROGRAM/PROJECT?	YES ☒ NO ☐	IDENTIFY PROJECT TITLE, NUMBER, ETC. High Energy Eye Safe Laser (HEESL) SE (NP1ADH15B1)

7. RELATED DOCUMENTS

A. ARE THERE ANY RELATED INVENTION DISCLOSURES OR PATENT APPLICATIONS?	YES ☐ NO ☒	IDENTIFY FILE OR CASE NUMBER, ETC.
B. ARE THERE ANY RELATED ISSUED PATENTS OR TECHNICAL PUBLICATIONS?	YES ☐ NO ☒	IDENTIFY

8. USE, COMMERCIALIZATION AND FOREIGN MARKETS

A. ARE YOU AWARE OF ANY POTENTIAL COMMERCIAL APPLICATIONS FOR THE INVENTION?	YES ☒ NO ☐	IDENTIFY POTENTIAL CUSTOMER, APPLICATION, TIME FRAME
B. ARE YOU AWARE OF ANY FOREIGN MARKETS FOR THIS INVENTION?	YES ☒ NO ☐	IDENTIFY COUNTRIES, APPLICATIONS, TIME FRAME
C. HAS THE INVENTION BEEN OR IS THE INVENTION TO BE INCORPORATED INTO A COMPANY PRODUCT OR PROGRAM?	YES ☒ NO ☐	PRODUCT(S) OR PROGRAM(S), TIME FRAME

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9. **DEPARTMENT MANAGER COMMENTS TO PATENT EVALUATION COMMITTEE**

NAME	SIGNATURE	DATE	PHONE
Douglas A. Anderson Doug	[signature]	10/31/02	647-0814

NAME	SIGNATURE	DATE	PHONE
Rolanda Gotfried	[signature]	11/7/02	310 334-7655

11. SUPERVISOR: please affirm the charge number and program data provided in sections 3, 4, 5, and 6 of this disclosure.

SUPERVISOR NAME	SIGNATURE	DATE	PHONE
Maurice Halmos	[signature]	11-04-02	310-647-0958

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	DATE RECEIVED	PATENT DOCKET NUMBER
High power Er:crystal fiber-based laser with robust coherent phase locking technique IP/INDSC REV. 5/1/2000 PAGE 3 OF 13	NOV 07 2002	02W202

TITLE OF INVENTION

High power Er:crystal fiber-based laser with robust coherent phase locking technique

INVENTOR(S) (Additional Inventors may be listed in Section 14)

Kalin Sparlosu	Alexander A Betin	

12. PUBLICATION, SALE, OR PUBLIC USE

A. HAS THE INVENTION BEEN DISCLOSED TO A THIRD PARTY WITHOUT THE EXECUTION OF A NON-DISCLOSURE, PROPRIETARY, OR OTHER CONFIDENTIALITY AGREEMENT?	YES ☐ NO ☒	DATE	TO WHOM
B. HAS THE INVENTION BEEN USED, DISCUSSED, DEMONSTRATED OR OTHERWISE DISCLOSED OUTSIDE THE COMPANY (SUCH AS TO A VENDOR OR CUSTOMER)?	YES ☐ NO ☒	DATE	TO/FOR WHOM (COMPANY/PERSON)
C. HAS THE INVENTION BEEN SOLD OR OFFERED FOR SALE?	YES ☐ NO ☒	DATE	TO WHOM
D. IS THERE A PUBLICATION OR PUBLIC PRESENTATION RELATED TO THE INVENTION? (This includes the Internet)	YES ☐ NO ☒	DATE	IDENTIFY
E. HAS A MANUSCRIPT DESCRIBING THE INVENTION BEEN SUBMITTED FOR PUBLICATION?	YES ☐ NO ☒	DATE	TO WHOM
F. IF THE ANSWER TO E. WAS YES, HAS THE MANUSCRIPT BEEN ACCEPTED FOR PUBLICATION?	YES ☐ NO ☐	DATE	WHEN AND WHERE WILL IT BE PUBLISHED?

INVENTOR(S) SIGN AND DATE:

[signature] 10/31/02 [signature] 10/31/02

WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE	WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE

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13. SUMMARY OF THE INVEN... N

A. STATEMENT OF THE PROBLEM SOLVED BY THE INVENTION

The is currently a need for a compact robust solid-state laser operating directly at eye-safe wavelength(s) that is easily scalable to high average powers and high pulse energies for a variety of airbome applications. In addition, the implementation of a weapons-grade solid-state laserbased on a eye-safe wavelngths of operation is desired by the defense industry - and currently does not exist.

B. PRIOR ATTEMPTS OF OTHERS TO SOLVE THIS PROBLEM

The attempts to solve the compact eye-safe laser problem included Nd:YAG lasers with frequency conversions such as Raman and optical parametric oscillators (OPOs). These systems are inherently bulky and cannot be readily scaled to high energies as they require a very large number of pump sources to make a compact airborne platform itegration inpractical. Er lasers that lase directly at eye-safe lasers have traditionally been based on glass hosts which severly limits the thermal handling of these systems which in turn limits the power scalability. Although phase locking of multiple core fiber (MCF) lasers has been demonstrated, these systems rely on the Talbot effect (based on periodical structures) to phase lock. This phase locking technique is limited as it requires extremely precise length equalization of the individual cores and is highly dependent on the individual power output in each core. Furthermore, there is a limit how many elements can be locked in this way because of multiplexing issues in the common cladding. Namely, for adding tens of elements in a MCF type configuration, the Talbot effect would suffice; however, to extend the scaling to multi-kW powers will invariably require separate fiber laser oscillators. In that case, the Talbot effect by itself woulf not posses the required robustness to perform and effective phase locking.

C. HOW YOUR INVENTION SOLVED THIS PROBLEM

The approach we propose is the implementation of Er:YAG crystal fiber laser oscillators directly coupled and pumped by high power diode lasers. In this way high power diode laser arrays (comprising of several bars each) would have "pigatil" coupled Er:YAG crystal fiber oscillators which will subsequently be phase locked - combined - via a robust external cavity technique that does not rely on precise oscillator cavity lengths implementation and does not require identical individual element output powers to efficiently phase lock - combine.

D. WHY YOU BELIEVE THAT THE INVENTION IS NEW (Specifically point out all novel features)

14. DETAILED DESCRIPTION.

Use the Invention Disclosure Continuation Sheet to provide a detailed written description of your invention, using as many pages as necessary. Be certain to include a description of the "best mode" or best means of practicing the invention known to you at this time. You may insert figures, tables, and photos into this section, or you can attach copies of relevant proposals, prior art, or other documentation that will assist the Patent Evaluation Committee in fully considering your invention. (Note: Please place information on additional inventors first in this section).

INVENTOR(S) SIGN AND DATE: [signature] 10/31/02 / [signature] 10/31/02

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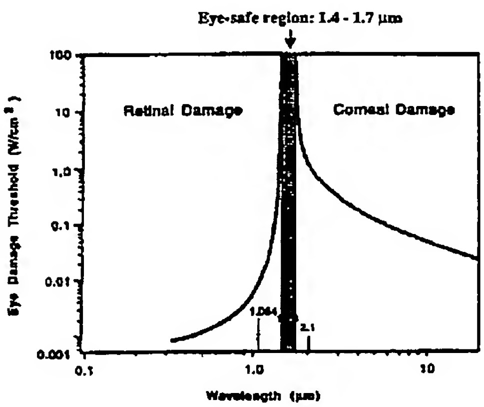
High energy solid-state lasers (Yb:YAG, Nd:GGG - 1 micron wavelength) are gaining ground in development towards achieving weapons-grade status. One obvious shortcoming for such lasers is the collateral damage it may produce to friendly forces. Namely, even with laser protection goggles, eye damage risks due to secondary and tertiary glint reflection could end up inducing permanent eye damage to friendly troops. Clearly, then, equivalent laser sources that would have many orders of magnitude higher damage thresholds would be critical for practical eventual implementation of such directed energy (DEW) systems.

Lasers operating in a narrow region from about 1.4 μm to 1.8 μm where the vitreous humor absorbs strongly exhibit several orders of magnitude increase in human eye damage threshold:



Eye damage threshold as a function of laser wavelength

(courtesy of Dr. Larry DeShazer)

Resonantly pumped Er:YAG laser , which lases directly within the "eye-safe" wavelength window, is very similar to the Yb:YAG laser: it is pumped directly into the upper laser excited state and has a small quantum defect ensuring high efficiencies and low thermal loading:

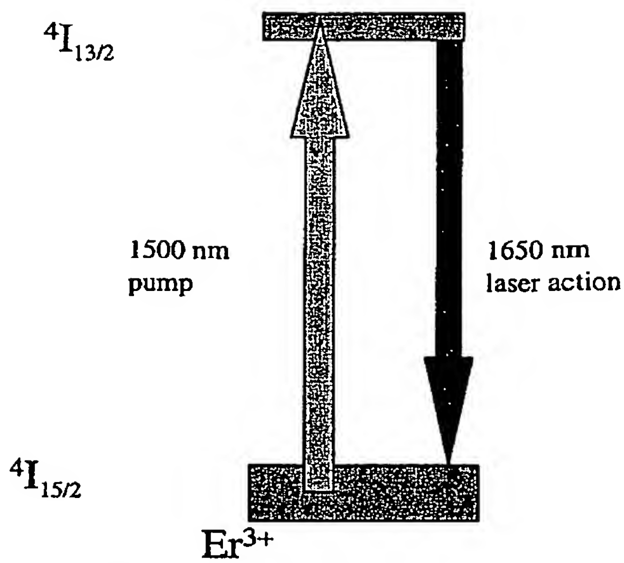


Figure 2. Resonantly pumped Er:crystal laser dynamics

Unlike Yb, however, Er does have upper lying energy levels, which could introduce parasitic losses due to upconversion and/or excited state absorption – as shown below:

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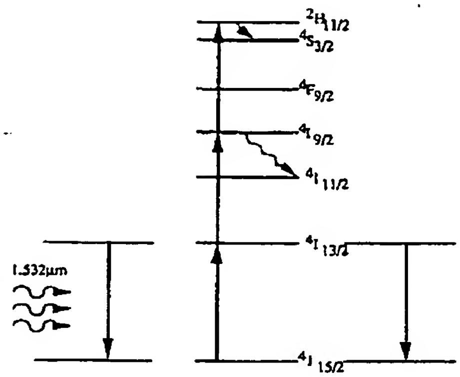

Er:crystal upconversion dynamics

This, fortunately only become significant at high Er concentrations[1]. At small Er concentrations (< 0.5 % doping), the parasitic losses are insignificant and achievable optical-optical efficiencies can be as high as 50 %; however, the pump absorption is small requiring relatively long absorption lengths. In a standard laser at an eye-safe configuration, this becomes an issue also from the point of view of sensitivity to diode laser temperature dependent operating wavelength.

Our innovative high energy eye-safe laser approach leverages the following key features of the Er:YAG laser gain medium:

- Resonantly pumped highly efficient low Er concentration gain medium
- High absorption efficiency and insensitivity to temperature variations in an elongated Er:YAG fiber structure (YAG fiber synthesis was demonstrated[2,3]).
- Excellent energy storage capability of Er:YAG (even better than in Yb:YAG lasers), but higher gain than in Er:glass and negligible re-absorption (since in YAG host Er is essentially a quasi-four level laser). This drastically reduces red-shifting which can affect the overall stability of the phase locker.
- Scaleable to multi-kW power levels via phase phase locking technique without compromising the modular pump-fiber laser structure.
- Direct diode pumped – multiplexed system with inherent compactness and integration flexibility:
- Thermal management-friendly laser configuration inherent in fiber lasers / amplifiers

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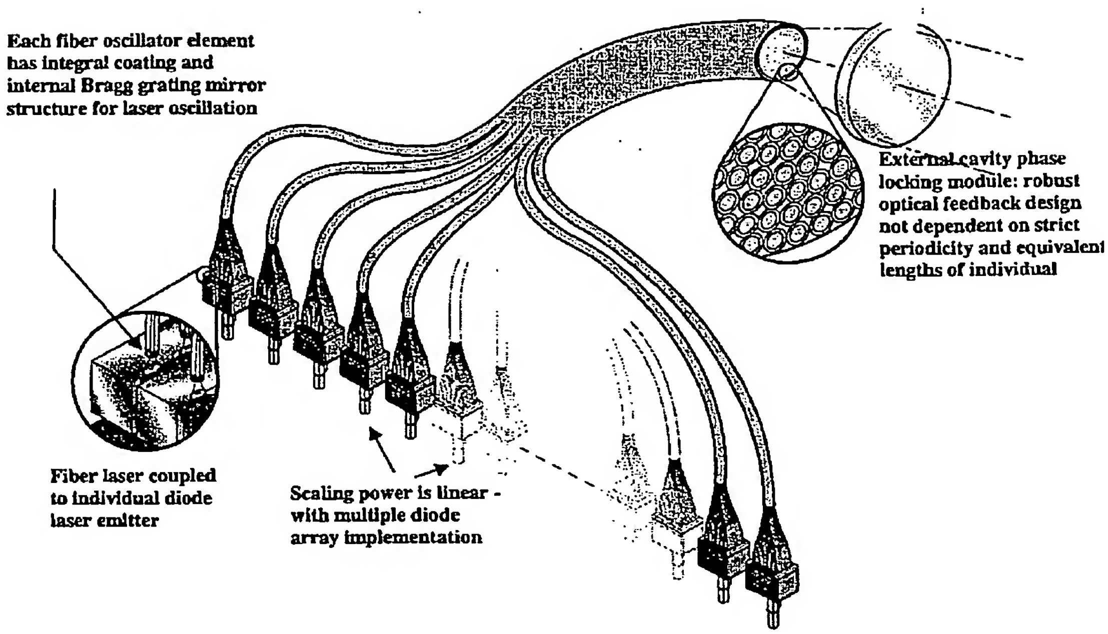

Er:YAG fiber laser system showing modular structure scalable to multi-kW power levels.

The phase locking external cavity is shown below:

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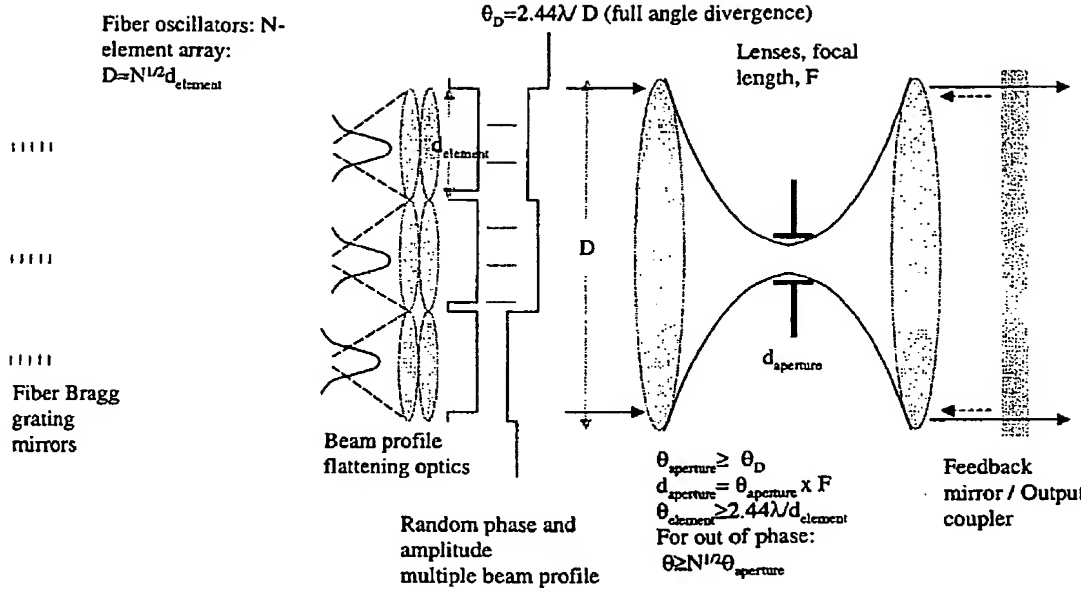

The individual fiber lasers will have a random phase and amplitude profile as shown above. The collimating lenses for each of the individual oscillators will provide for top hat intensity profiles. Placing an aperture in the transform plane of an external cavity lens pair followed by a feedback mirror / output coupler will ensure that only the field components that are in phase will exhibit significant feedback as the completely out-of-phase components will be lossy and, therefore, suppressed. The aperture can either be a simple pin-hole type aperture for only the fundamental mode feedback, or a fitted (matched) aperture with side lobes generation. The diffraction of the entire system – assuming single phase matched wave front – is based on the effective aperture size of the collimating lens pairs, D. The coherent diffraction angle is then $\theta_{coherent} = \frac{2.44\lambda}{D}$, and the spot size is $d_{coherent} = \theta_{coherent} \times F$, where F is the focal length of the common lenses. It clearly follows that for the individual elements, the diffraction angle – in the non phased case – is $\theta_{element} = \frac{2.44\lambda}{d_{element}}$ (this could be $\theta_{element} = \frac{2\lambda}{D}$ in the case of a true square symmetry). Since in a symmetrical 2-D arrangement of M elements, $D = \sqrt{M}\, d_{element}$, the diffraction angle for the non- phased array is $\theta_{non-phased} = \sqrt{M}\,\theta_{coherent}$ and $d_{nonphased} = \theta_{nonphased}F$.

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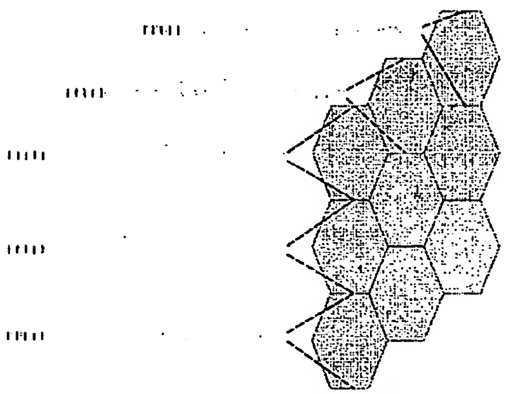
It clearly follows that with the facilit... ...n – allowance – of phase and frequency locki..., only the least lossy – phased – condition will dominate, as the out-of-phase components will exhibit a much higher loss and will, therefore, be suppressed. The relative transmission (per pass) of the non-phased mode is $T \sim (d_{coherent} / d_{nonphased})^2$. Clearly, the completely non-phased mode will be extremely lossy and will not be sustained. The partially phased locked modes – even with only a small fraction of the oscillators out of phase will see a reduction in transmission – hence – gain and will be suppressed. For the target number of – say – 100 oscillators, the scenario of even one pair of oscillators being out of phase will result in $\tilde{a}$ 2 % loss per pass. This is still a viable operation condition for the implementation of phase-locked operation.

In order to efficiently fill the two-dimensional space within the external cavity, a hexagonal mirror geometry could be implemented as shown below:



As stated earlier, this collimating lens array could transform the Gaussian TEM_{00} mode coming out of the single mode fiber oscillators to a flat top with >95 % efficiency which would be sufficient to facilitate efficient phase locking of the individual oscillators.

In order to effect phase – coherent – locking of individual fiber oscillators two conditions need to be satisfied:

1. The oscillators must operate with frequencies $\omega_j = \omega$ within the gain bandwidth, and

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2. The phases of the individual oscillators must match: $\varphi_j = \varphi$.

To achieve the first condition, one possible solution is to make the individual fiber oscillators of identical length. Although, one can in principle make the fibers identical in length, the oscillator cavity which is comprised of the the free space length from the fiber ends to the common output coupler is difficult to make exact in length for all the oscillators because of mechanical / thermal issues. Hence, making the fibers deliberately different in length with sufficient deviation such that frequency – longitudinal mode - overlap will occur within the gain bandwidth of the laser oscillation.

In a long cavity length oscillator of length, L, the mode-spacing defined by the resonator cavity is $\Delta\nu = \frac{c}{2L}$ or in terms of wavelength: $\Delta\lambda = \frac{\lambda^2}{2L}$. Here c is the speed of light and λ is the center (peak) laser wavelength. For a 2 m long resonator, the longitudinal mode spacing (for the 1645nm laser peak wavelength) is ≈0.007 Angstroms. For the typical linewidth of the Er:YAG transition of up to 1 Angstrom, the gain profile will support about 148 modes. As the length of these fibers varies, so does the mode spacing. For a length difference of >1.4 cm (for the 2 m long fiber), there will be mode overlap between the two dissimilar length oscillators - free spectral range (FSR) is exceeded for these length differences. For longer fiber oscillators (example 3 or 4 m), the length variation condition (for exceeding the FSR and ensuring mode overlap) of >1.4 cm still holds true since the number of modes increases with increasing fiber resonator length (221 modes for 3m long and 295 modes for 4 meter long resonators). Hence the mode spacing is reduced and the FSR is maintained for a particular length variation. Therefore, either ensuring precisely equal lengths of the YAG crystal fiber oscillators, or deliberately making these oscillators with varying lengths with length differences exceeding 1.4 cm will ensure that all oscillators will be capable of longitudinal mode overlap – hence capable of phase locking. Because Er:YAG crystal exhibits a sharp gain profile (unlike glass), the spectral purity of the overlaped –phase locked oscillator is maintained, so that no additional etalons are required to limit the "wavelength wander" of the individual oscillators.

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The phase differences of these individual oscillators can be described as: $\varphi_j = \varphi_n$ and $\varphi_{j+1} = (N+f)\frac{2\pi}{\lambda}L_{oscillator}$, where f<1 and N is an integer. That is, typical phases differences between adjacent oscillators will vary by many 2π cycles, thus ensuring that phase locking can be facilitated at some equal phase condition $\varphi_n = f\frac{2\pi}{\lambda}L_{oscillator}$ beyond the $N\frac{2\pi}{\lambda}L_{oscillator}$ full cycle offset. The phase fluctuations in the different oscillators can be expressed in terms of refractive index fluctuations: $\delta\varphi_j = \delta n_j \frac{2\pi}{\lambda}L_{oscillator}$ where $\delta n_j = \frac{\partial n}{\partial P_{oscillator}}\Delta P_{oscillator}$. A number of mechanisms can lead to δn depending on the active material, geometrical factors and so on. Typically, the change in the electron population among the various energy levels in an active lasing media will lead to a change in refractive index. In addition, slight changes in the heat distribution will also lead to a refractive index change. For instance, a conservative change in refractive index as a function of temperature of $\frac{\partial n}{\partial T} \approx 10^{-5}$ will result in a phase difference of 12.16 x 2π, or $N = 12, f = 0.16$ for a $1°C$ temperature change. Thus, clearly, phase locking of the individual oscillators will easily be facilitated in this system.

This phase locking techniques for combining many indivisdual oscillators can also be applied to Yb:glass fiber lasers/amoplifiers, micro-lasers arrays, and semiconductor lasers. Depending on the particular gain media, intra-cavity etalons can be added in order to restrict the gain profile (for insntance, in glass hosts and semiconductor lasers, the gain profile is typically much broader than in crystal host laser.)

References

[1] K. Spariosu, M. Birnbaum, and B. Viana, "Er^{3+}:$Y_3Al_5O_{12}$ laser dynamics: effects of upconversion," J. Opt. Soc. Am. B, 11 (5), 894 (1994).

INVENTOR(S) SIGN AND DATE:					
10/31/02 / Koki Spariosu 10/31/02					
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[2] Vatnik, Opt. Communicati .197, 375-378 (2001)

[3] Lo et al, OSA ASSL Proceedings, (2001)

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Exhibit 2

Raytheon
Colin M. Raufer, Intellectual Property Attorney

2000 East El Segundo Boulevard
P.O. Box 902
El Segundo, CA 90245-0902
310.647.1000

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CENTRAL FAX CENTER
OCT 07 2008

Direct Line: 310.647.3214
Facsimile: 310.647.2616

January 22, 2003

via Express Mail

William J. Benman, Jr.
BENMAN, BROWN & WILLIAMS
2049 Century Park E., Suite 2740
Los Angeles, California 90067

Re: Request for Preparation of U.S. Patent Application

PD-02W202 – HIGH POWER ER:CRYSTAL FIBER-BASED LASER WITH ROBUST COHERENT PHASE LOCKING TECHNIQUE
Inventors: Kalin Spariosu, Alexander A. Betin

Dear Bill:

We would appreciate your assistance in preparing a patent application for filing in the United States Patent and Trademark Office, based upon the above-entitled invention disclosure, copy of which is enclosed for your review.

To better manage expenses relating to the preparation and filing of the patent application, we request that you give the enclosed invention disclosure a cursory review to ascertain, not only the complexity of the case, but any additional time you feel may be necessary in order to complete and file the application.

Please note: This disclosure contains information that is considered to be Raytheon proprietary. Please treat it accordingly.

Also note: The expected date for completion of the final application is approximately Fifty (50) days from the date of this letter, i.e., **March 12, 2003**. Please inform us immediately if the expected date for completion cannot be achieved.

Unless informed to the contrary by **January 29, 2003**, we will assume that your cost estimates (fees and disbursements) for the preparation of this case will not exceed $6,500.00. In any event, it will be necessary for you to provide us with an estimate of your charges for preparing the patent application by signing

and returning the enclosed quotation checklist. If you are unable to supply or support any of these checklisted items, please address any issues or concerns in your estimate letter.

Specifically, your estimate should include all anticipated fees and disbursements (not including filing fees) for preparation of an application ready for filing in the United States Patent and Trademark Office. Your estimate shall be based upon a flat rate. We will prepare the formal papers, obtain inventor signatures and file the completed application.

The attached disclosure may be incomplete or additional embodiments may have been developed since its generation. Your estimate should include at least one interview with the inventors.

PLEASE INCLUDE THE COST OF PREPARING THE FORMAL DRAWINGS IN YOUR ESTIMATE. It will be necessary to provide us with the bristol boards, complete with four (4) sets of the formal drawings on smooth surface, calendar-finish paper without watermarks. In addition, please place the drawings on a computer diskette. To be acceptable, drawings must be legible and must meet USPTO and PCT requirements, and must be accompanied by a list identifying the name of the element and its callout number. The material composition must be specified for all cross-sectioned elements. If drawings have been prepared by the inventors and are available on disk, a copy should be provided. As discussed, if the USPTO objects to the original drawings prepared by your draftsman, any necessary corrections will have to be made by you at no extra charge to Raytheon. Henceforth, you will be requested to make all drawing corrections for drawings originally prepared by you. Therefore, please ensure that the drawings will be available (particularly if drawn by computer) so that corrections can be easily made.

If we accept your estimate and authorize you to prepare this application, you should submit all correspondence, including invoices with the following information:

1. The Raytheon Docket Number (PD-02W202);

2. The title of the case;

3. The inventor's name (as referenced above);

4. The name of the responsible Raytheon attorney; and

5. Itemized expenses rendered either on a per hour basis or flat rate for services plus a breakdown of costs and disbursements for postage, photocopying, telephone calls, travel and drafting.

Invoices are to be submitted upon completion of the application. **No partial billing will be accepted**. When forwarding any billing information to Raytheon, send the original documents to the attention of:

RAYTHEON COMPANY
P.O. Box 902
E0/E01/E150
2000 E. El Segundo Boulevard
El Segundo, CA 90245-0902
Attn: Ms. Elaine Panousis

To facilitate our filing of the United States Patent Application, please provide the application on A4 paper with any accompanying 3.5" diskette. Designate on the diskette the word processing program used to generate the patent application (preferably **MS Word 7.0**). We also require two sets of claims. The first set should be drafted for submittal to the United States Patent Office. The second set should not use "means" type claims, should include reference numerals within parentheses, multiple dependencies, and should include one independent method and one independent apparatus claim, if appropriate. Please try to limit the total number of claims of this second set to 10 claims or less if possible.

Do not hesitate to contact me with any further questions regarding this matter. Thank you for your attention to this request.

Sincerely,
RAYTHEON COMPANY

Colin M. Raufer
Colin M. Raufer
Intellectual Property and Licensing

CMR/jws
Enclosures: Invention Disclosure
Quotation Checklist

Exhibit 3

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& RELATED CAUSES

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VIA PRIORITY MAIL

May 7, 2003

Re: Preparation of a Patent Application for PD-02W202
SCALABLE LASER WITH ROBUST PHASE LOCKING
Inventor(s): Kalin Spariosu and Alexander Betin